The Behaviour of Air Rifle Pellets in Ballistic Gel

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Introduction

Although air weapons are considerably lower in power than other firearms, there is increasing concern that serious injuries can result from their misuse. The present study was therefore carried out to improve understanding of the terminal ballistic behaviour of air rifle pellets. Pellets were fired into ballistic gel under a variety of conditions, and the pellets penetrated further than anticipated from their low cross sectional density. Test firings were also carried out firing pellets into ballistic gel that contained sections of animal bone and computed tomography (CT) and visual observation were employed to record the interactions.

Background

Extensive research has been conducted on various aspects of firearms, but much less work has been carried out into air weapons. The rationale for focussing research on more powerful weapons is obvious - they create more damage and can be lethal. The perceived wisdom has been that airguns are less hazardous because the projectile has much lower energy: 16.3 J compared with 100-600 J for handguns, and 1000-3500 J as a typical range for rifles. However, within the UK most firearms offences are by air weapons. The majority of these are lesser offences such as vandalism, and minor assault but a number of incidents occur with serious or fatal outcomes. This study was therefore carried out to develop understanding of the behaviour of air pellets.

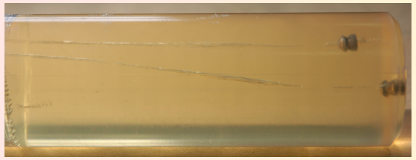

Fig 1. Pellet tracks in gel contained in a knife holder

Experimental Method

Details of the study are given in reference [1].The basic method of gel preparation employed was that described by Jussila [2] i.e. the gel powder was mixed with cold water initially to hydrate it and hot water was then added. Four air rifles were used to deliver different power and various variables were examined. In another phase of the study a section from a cow femur was placed in the gel. As the bone had a relatively flat face this was positioned at a predetermined angle to the line of firing. The femur was placed at 5, 10, 20, 30, and 40 mm from the front face of the gel and inclined at an angle of 0, 25, 50 and 75 degrees to the firing line. After firing the gel was photographed and any observations were recorded before the pellets were removed. For 15 of the bone samples, the specimen was taken for examination by computed tomography (CT) scanning before removing the bone from the gel. CT scanning uses x-rays to take a series of 2-D image 'slices' through the object and these are combined by computer to produce a 3-D image.

Behaviour of Pellets in Ballistic Gel

Most authors use a 10% gel but in the present study this did not give the expected stopping distances. Based on Jussila's work [2] it had been anticipated that pellets would come to rest within 80 mm, but pellets penetrated further and rebounded off the plastic base of the knife holder (figure 1).Air rifle pellets have a low cross-sectional density and the degree of penetration into gel needs further examination to confirm whether penetration is greater than expected. A detailed study was therefore carried out of gel properties and their effect on pellet behaviour. The four gels examined all came within their manufacturer's specification. The effect of variables such as Bloom strength, gel concentration, firing distance, air rifle power, and pellet shape were all examined and the effect of changes in these variables were as expected. Figures 2 and 3 indicate the effect of gel concentration, power and range on penetration.

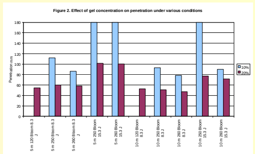

Fig 2. Penetration of gel

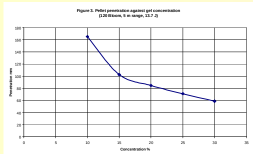

Fig 3. Effect of gel concentration

CT Scanning of Bone in Gel

CT scanning showed potential as a tool for examining pellet damage. The bone appeared to be undamaged, and most of the CT Scans appear to show no evidence of density change in the bone due to compaction, although some may show evidence of 'wipe' of lead from the pellet. The pellets were severely deformed on impact. If the pellet strikes the bone at an angle, less energy is absorbed by the impact and the pellet fragments can ricochet and cause further damage in the gel. One advantage of CT scanning is the ability to differentiate different materials and to filter out the bone, thus allowing examination of the pellets in situ by rotating the image in 3 dimensions. Figures 4 and 5 present 2-D images to demonstrate this.

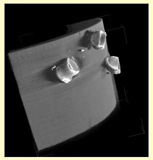

Fig 4 CT Scan of bone and pellet

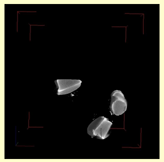

Fig 5 Bone filtered from scan

Interaction of Pellet with Bone

The length of the pellet tracks in the gel were measured, and the dimensions of the pellet fragments were recorded after they were recovered from the gel. As expected, the deeper the bone is mounted in the gelatin, the less damage is caused to the pellet. It would be expected that a deeper depth of gelatin would slow down the pellet and absorb the energy from the pellets, resulting in lower impact energy. Most damage to the pellet occurs with the smaller angles (direct impact) rather than the larger angles (oblique impact), e.g. at 75º the pellet is deflected and less pellet damage is caused, whereas at 25º, the pellet has a tendency to be stopped upon impact rather than being deflected. Consequently, the distance travelled after impact depends on the angle of incidence.

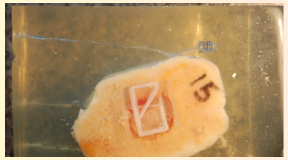

Fig 6 Impact of pellet on bone

Fig 7 Damage to pellet

Some of the pellets hit the bone at a corner or an edge which resulted in some interesting observations, as shown in figure 6. As the pellet approaches the corner or edge of the bone in a straight line, it seems to curve in towards the bone at a distance of about 5mm from the bone. This is unusual as most of the other shots impacted the bone along a straight line. Reasons for this are unknown, but could possibly be due to gel displacement affecting the trajectory of the pellet as it approaches the bone and the gel in the area ahead of the pellet being less elastic due to the nearby presence of the bone.

Energy on Impact

These trials did not include material to simulate skin, and the effect of the impulse at phase boundaries needs to be considered. Despite this limitation, an attempt was made to estimate the energy losses for each part of the pellet flight in order to determine the energy loss on impact with the bone. To develop this model it was assumed that the pellet experienced a constant retarding force from the gel as the gel yielded, but further studies are required.

Future Work

Studies are currently being carried out to examine the effect of air rifle pellets on both hard and soft materials and these will be reported when completed.

Conclusions.

Air rifle pellet penetration in ballistic gel under various conditions has been examined. CT scanning has been used to examine the impact on bone and energy losses during impact have been discussed.

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References

1. Wightman, et al., An investigation into the behaviour of air rifle pellets in ballistic gel and their interaction with bone, Forensic Sci. Int. (2010), doi:10.1016/j.forsciint.2010.03.025

2. Jussila J., Preparing ballistic gelatine – review and proposal for a standard method, Forensic Science International 141 (2004) 91-98